REMARKS

By the present amendment and response, claims 1, 9, 26, and 35 have been amended to overcome the Examiner's objections and claims 18, 21, 28, and 37 have been canceled. Thus, claims 1, 2, 4-9, 17, 19-20, 22, 26-27, 29, and 31-36 remain in the present application. Reconsideration and allowance of pending claims 1, 2, 4-9, 17, 19-20, 22, 26-27, 29, and 31-36 in view of the above amendments and the following remarks are requested.

A. Rejection of Claims 1-2, 6, 9, 17-18, 20-21, 26-28, 29, 33, and 35-37 under 35 USC §103(a)

The Examiner has rejected claims 1-2, 6, 9, 17-18, 20-21, 26-28, 29, 33, and 35-37 under 35 USC §103(a) as being unpatentable over U.S. patent number 5,880,516 to Toru Yamazaki (hereinafter "Yamazaki"). For the reasons discussed below, Applicant respectfully submits that the present invention, as defined by amended independent claims 1, 9, 26, and 35, is patentably distinguishable over Yamazaki.

The present invention, as defined by amended independent claims 1 and 26, includes, among other things, forming a buried layer in a semiconductor substrate, providing an epitaxial layer in the substrate, where the epitaxial layer is situated over the buried layer, selecting a first peak dopant concentration and a first implant energy such that at least one of capacitance, leakage current, and tuning range of a varactor device is optimized, forming a first implant in the epitaxial layer using the first implant energy, and

forming a second implant in the epitaxial layer , where the first and second implants are situated over the buried layer, and where the first and second implants, the epitaxial layer, and the semiconductor substrate have a first conductivity type and the buried layer has a second conductivity type. As disclosed in the present application, the present invention provides a method of fabricating a varactor diode having low leakage current, high tuning range, and a high quality factor (Q) by utilizing an innovative double-implant process.

As disclosed in the present application, first and second implants are formed in an epitaxial layer in an implant region of a semiconductor substrate, where the first and second implants have first and second peak dopant concentrations and first and second implant energies, respectively, and where the first and second implants and the epitaxial layer are situated over a buried layer formed in the semiconductor substrate. As disclosed in the present application, the first and second implants, the epitaxial layer, and the semiconductor substrate have a first conductivity type and the buried layer has a second conductivity type. For example, the first conductivity type can be P type conductivity and the second conductivity type can be N type conductivity. As disclosed in the present application, by appropriately selecting the first peak dopant concentration and first implant energy of the first implant, the present invention advantageously achieves a double-implant varactor device having at least an optimized capacitance, leakage current, or tuning range.

Also, as disclosed in the present application, by appropriately selecting the second peak dopant concentration and the second implant energy such that the second implant is

disposed below the first implant, the present invention achieves a double-implant varactor having minimized base resistance and, consequently, an optimized Q. Thus, present invention advantageous achieves a varactor wherein all of the varactor's parameters, i.e. capacitance, leakage current, tuning range, and base resistance, can be advantageously optimized by appropriately selecting the first and second peak dopant concentrations and first and second implant energies of first and second implants, respectively.

In contrast, Yamazaki does not teach, disclose, or suggest forming a buried layer in a semiconductor substrate, providing an epitaxial layer in the substrate, where the epitaxial layer is situated over the buried layer, selecting a first peak dopant concentration and a first implant energy such that at least one of capacitance, leakage current, and tuning range of a varactor device is optimized, forming a first implant in the epitaxial layer using the first implant energy, and forming a second implant in the epitaxial layer , where the first and second implants are situated over the buried layer, and where the first and second implants, the epitaxial layer, and the semiconductor substrate have a first conductivity type and the buried layer has a second conductivity type. Yamazaki is directed to improving the operation speed of a bipolar transistor in a low-current injection region to a high-current injection while suppressing the Kirk effect. Yamazaki specifically discloses sequentially forming n-type buried layer 2 and n-type epitaxial layer 3 on p-type semiconductor substrate 1. See, for example, column 4, lines 63-65 and Figure 3 of Yamazaki.

In Yamazaki, first, second, and third n-type pedestal collector regions 102, 103, and 104 are sequentially formed in n-type epitaxial layer 3 immediately below emitter region 12. See, for example, column 5, lines 16-19 and Figure 3 of Yamazaki. Thus, in Yamazaki, buried layer 2, epitaxial layer 3, and first, second, and third pedestal collector regions 102, 103, and 104 have n-type conductivity, while semiconductor substrate 1 has p-type conductivity. In contrast, amended independent claims 1 and 26 specify that the first and second implants, the epitaxial layer, and the semiconductor substrate have a first conductivity type and the buried layer has a second conductivity type. Thus, the varactor device achieved by the present invention is substantially different than the structure disclosed by Yamazaki. Furthermore, Yamazaki fails to teach, disclose, or remotely suggest a method of forming a varactor device on a semiconductor substrate, where first and second implants are situated in an epitaxial layer that is situated over a buried layer, and where the first and second implants, the epitaxial layer, and the semiconductor substrate have a first conductivity type and the buried layer has a second conductivity type.

Furthermore, as disclosed in the present application, the present invention achieves a varactor that comprises a base-emitter junction of a specially optimized NPN device formed with a double base implant. In contrast, in Yamazaki, all three pedestal collector regions (i.e. pedestal collector regions 102, 103, and 104) are formed as a group to suppress the Kirk effect in a bipolar transistor without increasing base-collector parasitic capacitance. See, for example, Yamazaki, column 6, lines 31-39. Furthermore,

Yamazaki does not even mention a varactor device, much less optimizing a varactor device.

For the foregoing reasons, Applicant respectfully submits that the present invention, as defined by amended independent claims 1 and 26, is not suggested, disclosed, or taught by Yamazaki. As such, the present invention, as defined by amended independent claims 1 and 26, is patentably distinguishable over Yamazaki. Thus claims 2 and 6 depending from independent claim 1 and claims 27, 29, and 33 depending from amended independent claim 26 are, *a fortiori*, also patentably distinguishable over Yamazaki for at least the reasons presented above and also for additional limitations contained in each dependent claim.

Amended independent claims 9 and 35 recites similar limitations as amended independent claims 1 and 26. Additionally, amended independent claims 9 and 35 recite, among other things, selecting a second peak dopant concentration and a second implant energy with relation to a first peak dopant concentration and a first implant energy such that the base resistance of a varactor device is minimized. As discussed above, Yamazaki fails to teach, disclose, or remotely suggest forming a varactor device on a semiconductor substrate, where first and second implants are situated in an epitaxial layer that is situated over a buried layer, and where the first and second implants, the epitaxial layer, and the semiconductor substrate have a first conductivity type and the buried layer has a second conductivity type. Thus, for at least the reasons discussed above, amended independent claims 9 and 35 are also patentably distinguishable over Yamazaki. Thus claims 17 and

20 depending from amended independent claim 9 and claim 36 depending from amended independent claim 35 are, *a fortiori*, also patentably distinguishable over Yamazaki for at least the reasons presented above and also for additional limitations contained in each dependent claim.

B. Rejection of Claims 4-5, 7-8, 31-32, and 34 under 35 USC §103(a)

The Examiner has rejected claims 4-5, 7-8, 31-32, and 34 under 35 USC §103(a) as being unpatentable over Yamazaki in view of IBM Corporation (NN79013241), "Determination of Doping Profiles by Means of SIMS," IMB Technical Disclosure Bulletin, 1979, Vol. 21, Issue Number 8, pp. 3241-3242. As discussed above, amended independent claims 1 and 26 are patentably distinguishable over Yamazaki. Thus claims 4-5 and 7-8 depending from amended independent claim 1 and claims 31-32 and 34 depending from amended independent claim 26 are, *a fortiori*, also patentably distinguishable over Yamazaki for at least the reasons presented above and also for additional limitations contained in each dependent claim.

C. Rejection of Claims 19 and 22 under 35 USC §103(a)

The Examiner has rejected claims 19 and 22 under 35 USC §103(a) as being unpatentable over Yamazaki in view of U.S. patent number 3,770,519 to Siegfried K. Wiedmann. As discussed above, amended independent claims 1 and 9 are patentably distinguishable over Yamazaki. Thus claims 19 and 22 depending respectively from

amended independent claims 1 and 9 are, *a fortiori*, also patentably distinguishable over Yamazaki for at least the reasons presented above and also for additional limitations contained in each dependent claim.

D. Conclusion

Based on the foregoing reasons, the present invention, as defined by amended independent claims 1, 9, 26, and 35, and claims depending therefrom, is patentably distinguishable over the art cited by the Examiner. Thus, claims 1, 2, 4-9, 17, 19-20, 22, 26-27, 29, and 31-36 pending in the present application are patentably distinguishable over the art cited by the Examiner. As such, and for all the foregoing reasons, an early Notice of Allowance for claims 1, 2, 4-9, 17, 19-20, 22, 26-27, 29, and 31-36 pending in the present application is respectfully requested.

Attorney Docket No.: 02SPE133P

Respectfully Submitted,
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Date: 2/15/05

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